Research Article

Smallholder Beef Cattle Husbandry and Fattening Practices in Rural Production System of Ethiopia

Amistu KU[1,2*], Monahan FJ[2], Wims P[2], Yonatan KY[1] , Fahey AG[2], Takele TA[3]

[1]Department of Animal Science, College of Agriculture, Wolaita Sodo University, P.O. Box, 138, Wolaita Sodo, Ethiopia; [2]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin 4, Ireland; [3]School of Public Health, College of Health Science and Medicine, Wolaita Sodo University, P.O. Box, 138, Wolaita Sodo, Ethiopia.

Abstract | The study was carried out to assess the beef fattening practices and management in the Wolaita zone, southern Ethiopia. Three districts representing three agro-ecologies were selected purposively based on their higher potential for beef cattle fattening and marketing. A cross-sectional study design was used to obtain data from local cattle fattening farmers (n=306) using a semi-structured questionnaire. The majority (94.4%) of respondents depend on the mixed crop-livestock farming activity as a source of income. The major feed resources for beef cattle fattening during the dry season are *Desho* grass (30.7%), hay (15.0%), and crop residues (14.7%) as basal diets, whereas for the rainy season fatteners almost fully depend on natural pasture (97.7%). However, fatteners use corn/fresh maize (87.7%), coffee leaf boiled together with water (44.4%), haricot bean (40.5%), cassava root (28.8%), mixed concentrates (21.6%), *enset* root (14.7%), and local brewery by-product (9.8%) as supplementary feed. The mean age of cattle when fattening began is 5.32±.08 years and fattening duration will take around 3.48±.05 months. Farmers fatten about 1.88±.05 cattle/fattening season and 1.74±.03 times /year. Decisions for finishing cattle is highly determined ($p<0.05$) by body condition change, weight gain, feed intake and market price. Moreover, cattle market prices are highly influenced ($p<.05$) by fasting season, market type/distance and body condition. Therefore, by-product-based beef cattle production systems are practiced in Wolaita, southern Ethiopia and are associated with low-input systems. These has to be improved if beef production in the area is to operate on a commercial basis.

Keywords | Beef cattle, Fattening system, Local feed resource, Fattening duration, Southern Ethiopia

Received | March 29, 2023; **Accepted** | April 20, 2023; **Published** | September 01, 2023
***Correspondence** | Amistu Kuma Urkato, Department of Animal Science, College of Agriculture, Wolaita Sodo University, P.O. Box, 138, Wolaita Sodo, Ethiopia; **Email:** amistu.urkato@ucdconnect.ie
Citation | Amistu KU, Monahan FJ, Wims Pàdraig, Yonatan KY, Fahey AG, Takele TA (2023). Smallholder beef cattle husbandry and fattening practices in rural production system of Ethopia. Adv. Anim. Vet. Sci. 11(10): 1597-1608.
DOI | http://dx.doi.org/10.17582/journal.aavs/2023/11.10.1597.1608
ISSN (Online) | 2307-8316

INTRODUCTION

Ethiopia has the largest livestock population in Africa, with nearly 73 million cattle, over 42.9 million sheep and 52.5 million goats, and 57 million chickens in 2020. Among these, 99.4% of the total cattle in the country are local breeds and the proportion of hybrid and exotic breeds is too small, at only 2.3% and 0.31%, respectively. While the percentage of beef cattle (i.e., cattle reared exclusively for meat) is about 1.2% (CSA, 2021). The sector contributed up to 40% of agricultural Gross Domestic Product (GDP), nearly 20% of total GDP, and 20% of national foreign exchange earnings in 2017 (Shapiro, 2017; World Bank, 2017).

Livestock plays a significant role in the national economy, particularly in rural areas, by generating income for farmers, providing draught power, ensuring food security, and

contributing to the asset, social, cultural, and environmental values, as well as sustaining people's livelihoods (Estefanos et al., 2014). Also, it is a source of high-quality food (meat and milk), industrial raw materials, and a family 'asset bank' for rural households (FAO, 2015; Bush et al., 2014; Gebremariam et al., 2013).

In Ethiopia, there are three types of beef fattening systems. These are the traditional highland practices, the by-product-based fattening system, and the Hararghe fattening system (MOA, 2004). In traditional systems, oxen are usually sold when they are in poor condition at the end of the ploughing season. The meat production from such oxen is low in terms of yield and poor quality, and farmer returns are usually insufficient to purchase a replacement ox under this system. The second is by-product-based fattening methods, which utilize agro-industrial by-products as the primary source of fattening feed in urban and peri-urban areas. Finally, the Hararghe fattening strategy involves purchasing young oxen, using them for two or three years, then fattening and selling them before they become malnourished. The methods rely heavily on the cut-and-carry feeding of tethered animals, and a modest quantity of concentrate is utilized to boost meat output (Ministry of Agriculture, 2004, Grebremichael et al., 2017).

Cattle are one of the most important livestock components in Ethiopia, where traditional cattle farming is practiced by 70% of the population (Belachew, 2019). Cattle in Ethiopia are nearly completely zebu, and they are quite well-adapted to the traditional production system (CSA, 2020). In Ethiopia, beef cattle fattening is a prevalent practice, and the government has paid special attention to beef cattle fattening to increase red meat supplies (Agmas and Adugna, 2018). Ruminants provide about 3.2 million tonnes of meat to Ethiopian meat production each year, accounting for over 72% of overall meat output, with beef accounting for 70% of that (Issack et al., 2017).

For achieving sustainable development goals (SDGs), particularly goals 1, 2, and 12, which are about eliminating poverty, zero hunger, and responsive and sustainable production and consumption, is crucial for ensuring food and nutrition security, as well as environmentally responsible beef production (FAO, 2018). Production systems in tropical nations like Ethiopia, on the other hand, vary depending on climatic conditions, livestock species and breeds, agricultural systems, feeding regimes, and technological utilization (Belayneh et al., 2021).

However, because of a lack of capital, technology, and an agricultural extension system for generating information and output, Ethiopia has not fully exploited its cattle and meat production capacity. Keeping these details in mind could help with the development of a remedy for the current problem. Meanwhile, some studies have been undertaken on smallholder farmers (Bezahegn, 2019; Teshager et al., 2013; Bekuma et al., 2020) and urban and peri-urban areas (Ahmed et al., 2017) in some parts of Ethiopia.

Wolaita Zone is one of the most densely populated areas in Ethiopia and is known for its rapid population growth that necessitates an increment in agricultural production. The mixed crop-livestock production system has been widely practiced in the area and there is a great potential for beef cattle production and market access. The area is distinguished by its large population of local cattle, high meat demand, and the existence of a superior market outlet. However, there is scant information on the beef cattle production system, local feed resources used for cattle fattening, fattening practices and marketing system in order to improve and know the status of smallholder beef cattle fattening in Southern Ethiopia.

Therefore, it is important to undertake a scientific study to generate information about smallholder beef cattle production, local feed resources used, routine management practices, traditional of cattle fattening practices and marketing in the area. The objective of this study was to document beef cattle production, management, and feed resources used among smallholder beef cattle farmers in Wolaita, Southern Ethiopia.

MATERIALS AND METHODS

The study was conducted at three districts (Damot Gale, Diguna Fango, and Offa) of Wolaita zone, Southern Ethiopia, which represents the three agro-ecologies (Highland, midland and lowlands). The traditional classification of agro-ecologies is based on elevation, crop growth length, rainfall pattern and temperature in Ethiopia into *Kola* (lowlands, 500-1,500 masl), *Woinadega* (midlands, 1,500-2,300masl) and *Dega* (highlands, 2,300-3,200 masl). Agriculture is the primary source of livelihood for 92% of the rural population in the zone, and mixed farming (crop production and animal production) has been dominant activity (Cochrane and Yishak, 2018). Specifically, Damot Gale district is located between 6° 55′ 00″ and 7° 10′ 00″ N Latitude and 37°45′0″ and 38°0′0″ E Longitude. It is located 350 km south of Addis Ababa and 153 km southwest of Hawassa capital of southern Ethiopia. The district is subdivided into 31 kebeles and has a total area of about 24,185.9 hectares. Mean monthly temperatures vary from 16 to 20°C. Average annual rainfall is 1250 mm. The altitude ranges between 1500 and 3500 m above sea level. The total population of the district is 51,079 with the density of Damot Gale being 664 persons/km^2 (Le Gal and Molinier, 2006; DGWMAO, 2014). Southern Ethiopia live-

stock population of 12,404,963 cattle, 4,735,6604 sheep, 4,819,573, goat and 7,347,205 poultry (CSA, 2020).

Diguna Fango district is located 42 km east of the zonal city named Wolaita Sodo, and South of Addis Ababa. Agro-ecologically, 73% of the total area is found within midland (moderate climate) and the remaining 27% is highland (moderately cold climate) (Chernet, 2018). The mean annual temperatures of the area range from 19.8 to 28.5°C and the average annual rainfall varies between 800 and 1200 mm (National Meteorological Service Agency, 2018).

Offa district is located in Latitude of 6° 44′ 59.99" N and Longitude of 37° 29′ 59.99" Eat 383 km south of Addis Ababa on the Sodo Gofa main road. The district has a total area of 37,356 ha and altitude is 1200 meters around river Gogara in the south (Alula et al., 2020).

Sampling procedure and sampling frame

Three-stage sampling technique was used to generate primary data. Firstly, the Damot Gale, Offa, and Diguna Fango districts were purposefully selected from Wolaita Zone to determine the beef production potential of the districts' predominant producers, production status, experience with local feed resources, and the volume of beef produced, fattening season and local market as compared to other neighboring districts in the Zone. In the second stage, from each district, three potential kebeles (smallest administrative unit) identified with help of experts and clustered to cover varying agro-ecologies. In the third stage, households were randomly selected with probability proportional to the size of identified kebeles from the study districts by using systematic random sampling by taking the n^{th} element of the sample frame. From the total of (4223) beef cattle producers in the selected area, 306 samples were obtained (Table 1) using Yamane's (1967) formula:

$n=N/(1+N)\ e^2$
Where:
n= sample size
N= Total population
e=margin of error (0.07) with 1.5 design effect used

Data source and data Collection

Both primary and secondary data were used for the study. The primary data was collected from smallholder beef cattle producer by using semi-structured questionnaire and data were collected on socio-demographic factors, beef cattle husbandry practices, local feed resources and feeding, seasonal variation of feed resources, selection criteria of beef cattle, housing, feeding/fattening practices (duration, frequency and number of cattle per season/households, decision on finishing of animals and marketing. Whereas the secondary data was obtained from livestock and fishery office of respective districts. Besides, personal observation was undertaken on different beef cattle management and feeding aspects during survey period to get general information on cattle fattening activities in the study areas. Amount of feed offered to fattening cattle per day was measured with local equipment farmers use and converted into kilogram. Before collecting the actual data, the questionnaire was pre-tested by using 30 households in the nearby village as quality control mechanism and to reduce bias. Informed verbal consent consistent with Wolaita Sodo University's ethical review policy was obtained from all respondents before the interview. Data were collected from June to October 2020.

Study variables

Beef cattle production (traditional, by-product based) was dependent variable whereas, beef cattle selection criteria, breeds of cattle, local feed resources, seasonal variation in feed resources, housing and feeding management, fattening cycle, fattening frequency, fattening length, marketing system and so forth were the independent variables.

Data analysis

Data were first checked manually for completeness and then coded, entered and analysed using Statistical Package for the Social Sciences (SPSS) version 26 software (SPSS, 2019). The relationship between the dependent variable and independent variables was determined using simple correlation and the association between the dependent variable and independent variable was evaluated by *chi-square* tests. One-way ANOVA was used to compute some quantitative (amount of feed offered per day(kg) across the study areas. The processed data were presented in tables in form of frequency, means, and percentage, and *chi-square* test for categorical data.

Ethical clearance

Ethical clearance consistent with Wolaita Sodo University Research Ethics policy was obtained from Institutional Review Board (IRB) reference number WSU/41/14/1023/22, June 2019.

RESULTS

Socio-demographic characteristics

The socio-demographic profile of the respondents is presented in Table 2. The educational background of the respondents was significantly different ($x^2=25.48$, $P=.013$) across agroecology, whereby the educational status was higher in midland than in lowland and highland agro ecologies. Similarly, the family size varied among households as well as agroecology, and the mean family size of respondents was 6.15±1.99 with a range of 2-12 family

members and significantly different (x^2=7.9, P=.035) across the area. The majority of study participants were male and significantly different (x^2=*9.48, P=.01)* across agroecology. The mean age of respondents was 43.56±0.63 years with a range of 21-68 years old (x^2=*8.91, P=.014*). The majority of respondents depended on mixed farming activity (animal husbandry and crop production) as a source of income (x^2=*514.29, p=.016*).

Criteria used for selection of cattle for fattening and beef cattle housing

Smallholder farmers in Ethiopia, particularly in the study area do not practice commercial (cow calf, stocker or grower and finisher) beef cattle production enterprise. Since there are no specialized beef type cattle in the area as result of low level of agricultural mechanization, low level of beef cattle technology and use of cattle for multiple purposes (milk, meat, power, manure etc), as result, smallholder fattener uses different criteria for selecting beef cattle for fattening. During the beef cattle selection process, more emphasis was given to body conformation, age, and both body conformation together with age than the sex and size of animals. Breed, sex and conformation of animal body were not significant (x^2=*4.95,*P=.089, x^2=*1.45,* P=.496 and x^2=*5.59,* P=.056) respectively across the study site.

The majority of respondents (92.5%) kept cattle apart from other animals during the fattening period and the housing practices for beef cattle varied between study areas (x^2=*35.33,* p=.000). Majority (32.8%) of study participants use separate house from human beings in lowland area. Beef cattle in the study area shares house with household family members but are kept in separate rooms as mentioned in Table 3 below.

Beef cattle breed

The majority of respondents (97.6%) fatten only local breed cattle, whereas 2.4% feed Holstein Friesian crossbred cattle with local cattle in the study area. The reason for fattening local cattle dominantly over pure exotic or temperate breed and cross breed in the area are high fattening cost (33.5%), not easily accessible in the area (30.8%) and low adaptation to the area (20.4%) shown in Table 4.

Feed resources for beef cattle fattening

Beef cattle fatteners provide three or more feed to their fattening cattle during rainy season, as is shown in Table 5. During the dry season (October-May), the most abundant roughage feed supplies are *Desho* grass (*Pennisetum pedicellatum*), hay, and crop residue. Maize (*Zea mays*) grain, cassava (*Manihot esculenta)* root, mixed concentrate, coffee leaf (*coffee abrabica*) and *enset (ensete ventricosum)* root, are also used as supplemental feeds. However, fresh maize, coffee leaf cooked with water, haricot bean (*Phaseolus vulgaris*), cassava root, *enset* root, local brewery, and wheat bran are the major viable feed supplies during the wet season (June to September), this period during which surplus green grass and forage available due to sufficient rainfall. A natural pasture (*Hyparrhenia rufa* and *cylodon* species) is utilized as a basal feed for fattening cattle by using cut-and-carry system. However, during dry (October-May) season feed shortage is critical problem in the area.

Supplementary feeding of beef cattle

The supplementary feeds provided for beef cattle are presented in Table 6. It emerged that maize grain is the most common supplementary feed followed by coffee leaf and cassava root used as beef cattle feeding during finishing. Average daily offer of mixed concentrate is significantly (P=.004) higher in highland agro-ecologies than lowlands areas. However, the use of boiled and/ fresh maize or corn, coffee leaf, cassava chips and sweet potato is significantly (P=.000) higher at lowlands agro-ecology.

Feed ingredient processing method

Different kinds of processing methods are practised for various feed ingredients as indicated Table 7 below. The majority of the fatteners use boiling, mixing with other feed, soaking, drying, and fermentation. *Enset* root, cassava root, sweet potato, and corn/fresh maize are processed by chopping before offering to the beef cattle. Nonetheless, concentrate feed is by mixing with water to make it easier to consume and avoid dusting.

Age, duration, and frequency of beef fattening

Cattle utilized for fattening in the area range in age from 4-8 years old, and most respondents (84.6%) fatten cattle that are five years old or above. The age at which cattle begin fattening was (x^2=39.23, *p=.001*) lower in the highlands (4.9±.19) years than in the lowland's areas (5.18±.12) years. In the study area, it takes an average of 3.46±.05 months for beef cattle to gain muscle. Most respondents (80.3%) fatten beef cattle for 3-4 months. The length of the fattening phase varies with the type of agro-ecology, with midland regions having a considerably shorter fattening time (*P=.001*).

The number of animals fattened per family during each fattening season/cycle is not significantly different (P=.92) between agro-ecologies. However, within agro-ecologies, the lowland area had a higher frequency of fattening each year (P=*.001*) than the highland and midland area. On the other hands, there is a correlation between the number of animals, the duration of fattening cattle, the fattening cycle each year, and the age of the animals. Furthermore, our findings revealed a positive but weak correlation (r) between the number of cattle fattened per cycle and the frequency of cattle fattened per year (r = 0.282; P=≤0.01).

Table 1: Sampling frame and sample size determination

District	Kebele*	Beef producer Households	Population Sampled households (%)	Number of households sampled
Diguna Fango	Diguna Offa Kalacha	427	10.1	31
	Diguna Boloso	332	7.86	24
	Arusi Woyde	575	13.6	42
Offa	Mancha	300	7.1	22
	Galda	609	14.2	44
	Wachiga Esho	797	18.87	58
Damot Gale	Buge	435	10.3	31
	Harto Kontola	443	10.49	32
	Wandara Boloso	305	7.3	22
	Total	4223	100%	306

*Kebele- the smallest administrative unit in Ethiopia containing hundreds of households

Table 2: Chi-square values for socio-demographic characteristics of respondents (N=306)

Variables	Agro-ecology					
	Description	Highland N=88	Midland N=125	Lowland N=93	Overall N=306	x^2	p-value
		%	%	%	%		
Family size	1-3	11.4	7.2	4.4	7.5	.019	.035
	4-7	69.4	49.6	80.7	64.8		
	8-10	15.8	42.4	15.1	26.5		
	>10	3.4	0.8	-	1.3		
Age (years)	21-30	12.5	19.2	10.8	14.7		
	31-40	35.2	30.8	35.5	33.3		
	41-50	28.4	23.2	35.5	28.4	476.9	.014
	51-60	17	16.8	12.9	15.7		
	≥61	6.8	10.4	5.4	7.8		
Gender of HH	Male	97.7	84.8	88.2	89.5	191.38	0.010
	Female	2.3	11.2	11.8	10.5		
Education	Illiterate	19.3	21.6	17.2	35.62		
	1-4	33	13.6	19.4	20.9		
	5-8	27.3	27.2	41.9	31.7	25.48	.013
	9-12	11.4	20.8	14	16		
	Diploma	3.4	6.4	0.0	3.6		
	Degree	3.4	7.2	4.3	5.2		
	Above degree	2.3	3.2	3.2	2.9		
Occupation	Farming activity	94.3	92.8	96.8	94.4		
	Gov't employment	3.4	2.4	1.1	2.3	514.29	.016
	Trade	2.3	4.8	2.2	3.3		

**=<0.05, ns=not significant, N=Number of respondents; x^2 = chi-square

The age of the animal, on the other hand, exhibits a negative but modest relationship with the number of cattle fattened per cycle (r=-0.120, P≤.05). However, there is no link between duration of fattening and number of cattle fattened per cycle/season (r=0.030, P>.05). Furthermore, farming experience shows a positive weak correlation with fattening frequency per year (r=0.120, p<.05).

Table 3: Distribution of respondents by criteria used to select beef cattle for fattening in study area (N=306)

		Agro-ecology					
	Variable	**Highland N=88**	**Midland N=125**	**Lowland N=93**	**Overall N=306**	**x^2**	**p-value**
		%	%	%	%		
Beef cattle selection	Age of animal	47.6	44.8	38.2	41.5	17.93	.000
	Sex of Animal	2.3	9.2	11.8	10.5	1.45	.496
	Color of Animal	6.5	9	20.8	4.7	11.36	.004
	Conformation of Animal	8.4	6.2	5.5	9.4	5.59	.056
	Breed of Animal	35.2	30.8	35.5	33.9	4.95	.089
Beef cattle housing	Special housing management	85	91.6	61	76	35.33	.000
	With human being	12.5	7	6.2	7	45.63	.009
	In separate house	2.5	1.4	32.8	17	40.05	.004

**=<0.05, ns=not significant, N=Number of respondents; x^2 = chi-square

Table 4: Distribution of respondents by reason fofr usng local breed cattle over temperate breeds for fattening in Wolaita (N=306)

	Reason for selection	**Frequency**	**%**
Reseason for low selection of temperate breed	Low market demand	48	15.3
	High fattening cost/feed consumption	103	33.5
	Low adaptation to the area	65	20.4
	Not easily accessible in the area	90	30.8

Table 5: Distribution of respondents based on feed resources used for cattle fattening during the wet and dry seasons.

	Agro ecology					
Feed resources	**Highland**	**Midland**	**Lowland**	**Overall**	**x^2**	**P-value**
Dry season (Oct.-May)[1]	N (%)	N (%)	N (%)	N (%)		
Roughage						
Desho grass	37(43.2%)	29(23.2%)	27(3.8%)	94(30.7%)	9.86	.007
Hay	15(17%)	19(15.2%)	12(12.9%)	46(15%)	0.61	.744
Crop residue	13(14.8%)	21(16.8%)	11(11.8%)	45(14.7%)	1.05	.609
Supplementary feeds						
Maize grain	40(45.5%)	50(40%)	63(67.7%)	153(50%)	17.43	.000
Cassava root	1(1.1%)	18(14.4%)	65(69.9%)	84(27.5%)	125.40	.000
Coffee leaf	15(17%)	15(12%)	42(45.2%)	72(23.2%)	35.47	.000
Mixed concentrate	27(30.7%)	29(23.2%)	18(19.4%)	74(24.2%)	3.27	.196
Enset root	21(23.9%)	29(23.2%)	8(8.6%)	58(19%)	9.33	.010
Haricot bean	29(33%)	5(4%)	18(19.1%)	52(17%)	31.21	.000
Sugar cane	13(14.8%)	16(12.8%)	9(9.7%)	38(12.4%)	1.10	.564
Local brewery by-product	27(30.7%)	0(0.0%)	0(0.0%)	27(8.8%)	73.35	.000
Wheat bran	27(30.7%)	1(0.8%)	2(2.2%)	30(9.8%)	60.99	.000
Molasses	6(6.8%)	0(0.0%)	1(1.1%)	7(2.3%)	11.61	.002
During wet season (June to September)[1]						
Roughage						
Natural pasture	85(96.6%)	123(98.4%)	91(97.8%)	299(97.7%)	0.76	.807
Supplementary feeds						
Fresh maize	76(86.4%)	116(92.8%)	75(80.6%)	267(87.3%)	7.17	.027
Coffee leaf	58(65.3%)	29(23.2%)	49(52.7%)	136(44.4%)	41.82	.000

Haricot bean	61(69.3%)	31(24.8%)	32(34.4%)	124(40.5%)	44.53	.000
Cassava	2(2.3%)	18(14.4%)	68(73.1%)	88(28.8%)	132.03	.000
Mixed concentrate	31(35.2%)	19(15.2%)	16(17.2%)	66(21.6%)	13.74	.001
Enset root	26(29.5%)	17(13.6%)	2(2.2%)	45(14.7%)	27.25	.000
Wheat bran	32(36.4%)	5(4%)	1(1.1%)	38(12.4%)	65	.000
Local brewery by-product	29(33%)	1(0.8%)	0(0.0%)	30(9.8%)	74.9	.000
Molasses	8(9.1%)	1(0.8%)	0(0.0%)	9(2.9%)	16.48	.000

*-significant at p-<0.05, **- significant at p-<0.01, ns-not significantly different

Table 6: Estimated Mean±SE different types of feed offered for fattening cattle (kg fresh/animal/day) across agro-ecologies in Southern Ethiopia

Feed Resources	Highland	Midland	Low	overall	p-value
Mixed concentrate	0.80±.07^{c}	0.56±.05^{b}	0.50±.06^{a}	.61±.03	.004
Fresh maize/corn	1.61±.09^{b}	1.47±.06^{a}	2.02±.12^{c}	1.68±.56	.000
Fresh haricot bean	0.95±.07^{c}	0.46±.05^{a}	0.70±.10^{b}	.67±.04	.000
Coffee leaf	0.75±.08^{b}	0.57±.07^{a}	1.68±.15^{c}	.97±.06	.000
Sweet potato	0.63±.11^{b}	0.27±.06^{a}	1.15±.14^{c}	.64±.06	.000
Wheat bran	0.35±.05^{c}	0.13±.04^{a}	0.20±.02^{b}	.16±.02	.000
Sun dried Cassava chips	0.78±.03^{b}	0.40±.08^{a}	1.86±.13^{c}	.75±.06	.000
Enset root	0.40±.06^{c}	0.36±.05^{b}	0.19±.05^{a}	.32±.03	.041
Molasses	0.09±.03^{c}	0.06±.02^{b}	0.00±.00^{a}	.05±.01	.076
Sugar cane	0.21±.02^{b}	0.20±.04^{a}	0.48±.10^{c}	.29±.04	.007

abc means with different superscript across rows are significant, SE-standard error of mean

Table 7: Processing method used for feed ingredient/items for beef cattle fattening.

	Maize grain+ haricot bean	Enset root	Mixed concentrate	Cassava root	Sweet potato root	Coffee leaf	Corn/Fresh maize
Processing Method	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Chopping/ milling	-	78(25.5)		97(29.7)	94(30.7)	2(0.7)	257(84)
Boiling	73(23.9)	-		3(1)	1(0.3)	142(46)	9(2.9)
Mixed with other feed	45(14.7)	-	9(2.9)	-	-	-	7(2.3)
Soaking and fermentation	31(10.1)	-	-	-	-	-	-
Drying	-	-	-	9(2.9)	-	-	-
Mixed with water	-	-	119(38.9)	-	-	-	-

Table 8: Mean±SE of age, duration, and number of cattle fattened in southern Ethiopia

Variables	Highland	Midland	Lowland	Overall	p-value
Age of animal for fattening(year)	4.9±.19^{c}	5.18±.12^{b}	5.80±.12^{c}	5.29±.08	.001
Duration of fattening(month)	3.65±.12^{a}	3.26±.07^{b}	3.54±.08^{c}	3.46±.05	.001
Frequency of fattening/year	1.69±.05^{c}	1.61±.05^{b}	1.98±.06^{a}	1.74±.03	.000
Number of animals/cycles	1.86±.07^{b}	1.92±.09^{a}	1.89±.12^{a}	1.9±.05	.921
Frequency of feeding/day	4.1±.11	3.07±..10	3.01±..08	3.35±..06	.000
Amount of mixed conc. Offer(Kg)	.84±..08	.56±..05	.50±..06	.62±..03	.001

SE-Standard error of mean, *abc means with different superscript across rows are significant, SE-standard error of mean*

Beef cattle finishing criteria

In the study area, smallholder farmers employ different criteria to decide whether to finish beef cattle. The main criteria used by the respondents are presented in Table 10. The visual estimate of the change in body condition as a criterion for finishing beef cattle is substantially different among districts (x^2=9.15, *P=.010*). Moreover, calculating beef cattle feeding period has a substantial impact on beef

Table 9: Correlation coefficient for age, duration cycle, and number of animals fattened/year in the area

Variable	Frequency of cattle fattened per year	Number of cattle fatten per cycle	Duration of beef cattle fattening in month	Age of cattle when fattening begins	Education-al level of household	Age of household	Family size of HH
Frequency of cattle fattening per year	1						
Number of cattle fatten per cycle	.282**	1					
Duration of beef cattle fatten-ing(month)	.058	.030	1				
Age of cattle when fattening begins	-.040	-.120*	-.021	1			
Educational level of household	-.006	.079	-.082	-.043	1		
Age of household (years)	.033	.090	.050	-.048	-.222**	1	
Family size of household	-.015	.052	-.009	.072	.057	.272**	1
Farming experience of HH (years)	0.120*	.078	-.012	.053	-.153	.034	.557**

Correlation significant at *=p<0.05 and **P<0.01

Table 10: Distribution of respondents by factors for deciding finishing of beef cattle in the study area

	Highland	Midland	Lowland	Overall		
Variables	N (%)	N (%)	N (%)	N (%)	x^2	P value
Body condition	31.2	35.2	33.7	32.5	9.15	.010
Weight change	27.6	25.9	36.5	32.1	3.22	.199
Reduction in feed intake	7.8	11.9	8.5	9.6	5.02	.081
Anticipated price (current &future)	30.5	22	12.3	18.8	.602	.746
Calculating feeding period	2.9	4.2	9	7	18.61	.000

**=significant at P<0.05, *=P=0.05 and ns=not significant

Table 11: Chi-square test for point of selling fattened cattle and factors influencing marketing price of beef cattle in the study area.

Variables		Highland	Midland	Lowland	overall		
		N=88 (%)	N =125)	N (%)	N (%)	x^2	P-value
Point of selling fattened cattle	Local market	71.6	73.6	83.8	76.3	2.287	.349
	National market	3.4	4	1	2.9	9.07	.010
	Neighbor	9	13.6	5.5	9.8	2.80	.252
	Butcher house	15.9	8.8	9.7	11	5.91	.049
Factors affecting market price of beef cattle	Fasting season	23.3	19.9	17.2	20.1	8.21	.016
	Presence of public holydays	28.7	22.6	16.7	24.7	17.66	.000
	Market type and distance	15.4	17.3	26.1	16.3	1.99	.391
	Color of Animal	7.7	10.8	15.7	11.3	2.53	.284
	Size and weight of animals	13.2	20.5	13.7	17.1	2.17	.337
	Fat level of cattle	11.7	8.9	10.6	10.5	5.65	.057

P<0.05-signficant and p>.05=not significant

cattle marketing (x^2=18.61, P=.000). However, the use of current and future price change and reduction in feed intake were not significantly (x^2=.602, *P=.746 and* x^2=5.02, *P=.081*) affect decision of finishing beef cattle in the area respectively.

Beef cattle Market outlet and factors influencing the market

Smallholder beef fatteners contribute to the local as well as the domestic/national markets. It emerged that 48% respondents sell fattened cattle by the involvement of middlemen/brokers. About 11% sell to butcher men, 76.3% domestic market. However, small proportion sell to 2.9% and 9.8% sell to wholesaler and neighbour respectively.

Beef cattle marketing in the area is influenced by different factors. Fasting season and presence of public holydays significantly (P=000) affects beef cattle marketing in the study area. Cattle prices do not remain consistent throughout the year and vary depending on a variety of factors, as stated Table 11.

DISCUSSION

The present study was aim to evaluate beef cattle husbandry practices, local feed resources and fattening practices and marketing in selected districts of wolaita, southern Ethiopia. The majority of the respondents had 1-6 years of fattening experience and respondents in the midland area had more experience than those in the lowland and highland areas. It is indicated that 57% study participants in west Hararghe, Ethiopia had 6-10 years of beef cattle fattening experience (Dinku, 2019). The majority of respondents depended on mixed farming activity (animal husbandry and crop production) as a source of income, similar to most highland parts of Ethiopia (Dinku, 2019, Estifanos et al., 2014).

Smallholder farmers in Ethiopia, unlike in affluent nations, are unfamiliar with modern beef production methods (Cow-calf, Stocker, and finisher program) (Gebremariam et al., 2010). The Ethiopian beef production system, on the other hand, is divided into three categories depending on feed and feeding systems: conventional, by-product-based, and Hararghe beef cattle production systems (MoA,2004; Abebe et al.,2022). According to the present survey, 57.4% of beef cattle farmers use by-product-based production systems. The major sources of feed for this system are various agro-industrial by-products, i.e., local brewery, coffee leaf, wheat bran, and mixed concentrates. Natural pasture is the major source of sustenance during the rainy season, whereas grass hay is used during the dry season. This finding is in line with Berhanu et al. (2018), who researched cattle fattening in Woliso Oromia, Ethiopia. Other than agroecology and agricultural systems, the existence of agro-processing plants and the accessibility of their by-products in the area have impacted the beef cattle production system in Ethiopia. The remaining 42.5% of fatteners, on the other hand, are classified as part of the traditional beef cattle system. Smallholder farmers buy young oxen and utilize them for crop cultivation (traction, weeding, and threshing) for 2-3 years before fattening and finishing them. This is due to traditional farming practices and lack of agricultural mechanization, which lead to the use of animal power for agricultural activities, resulting in lower meat output and quality, as well as lower profitability. The vast majority of beef cattle fatteners (97.4%) utilize local cattle breeds for fattening, whereas the rest employ local cattle crosses with non-beef cattle breeds (Holstein Friesian). Limited availability and accessibility, high fattening costs, and low adaption to the area were the reasons for the lesser utilization of cross and exotic beef cattle in the area. The cattle breed types used for fattening are mainly influenced by the accessibility of exotic beef cattle and feed availability. This is because exotic beef cattle are rarely found across the country and are produced in relatively small numbers on commercial beef cattle ranches. Farmers are also less interested in farming exotic cattle breeds due to their higher feed consumption than indigenous cattle breeds. However, this is not the case in all tropical nations. However, the present finding was higher than the reports of Ayalew et al. (2018), who reported 58.8% of cattle fatteners use local breed cattle in Gonder town, Amhara region, Ethiopia.

The majority of smallholder fatteners in the study area used cattle between the ages of 4-8 years, with an average age of 5.3 years. This is due to using cattle for draft power before being put into fattening because of low agricultural mechanization. This finding is in line with previous research (Berhanu et al., 2018; Bezahegn et al., 2019 ;Teklehymanot et al., 2017) which reported that smallholder farmers fatten cattle that are 3-6 years old in Oromia and Tigray regions, Ethiopia. Most smallholder farmers believe that too young animals do not fatten well owing to rapid growth and muscular development, require a long time to finish, and their market demand is low. This might be because, in most parts of Ethiopia, high-fat meat cuts are in high demand in the local market. The present finding agrees with Bekuma et al. (2020), Ahmed et al. (2017) and Belayneh et al. (2021), who reported that cattle are slaughtered at old age with accumulated high fat in Oromia, Western, Dessie and Kombolcha, and Dangila, Ethiopia respectively.

The vast majority of respondents (92.5%) keep fattening cattle apart from other classes and age groups of cattle in their homes. However, 10.8% of smallholder farmers keep their beef cattle apart from their homes. Beef cattle were isolated from humans and other animals by a wooden wall partition in a corrugated iron roof for dwellings. In addition, in the traditional Wolaita grass roof housing system, cattle are kept together with human beings with some kind of partition or enclosure locally known as "gaxaata" and fatteners cover partitions where fattening cattle are kept with different materials to ensure animals are not exposed to light and distracted by a human. This practice is common and unique to southern Ethiopia, particularly the Wolaita area. In contrast, Teklehymanot et al. (2017), found that fatteners in Northern Ethiopia used a complete wall with a corrugated roof housing style. However, the dwelling structure varies according to the household's economic, education status, number of animals retained, and agroecology.

During the wet season (June to September), is the only period during which feed is abundant unless feed shortage is high during dry season due to tropical climatic condition with high temperature and unreliable rainfall distribution across the agro-ecology. The major feed resources during this season are fresh maize, coffee leaf boiled together with water and haricot bean, cassava root, enset root, local brewery, and wheat bran used as a supplementary feed. During the rainy (wet) season surplus amount and types of feed resources are available for smallholder beef fattening. This finding is in contrast with Teklehaymanot et al. (2017), who reported that 64.8% of beef cattle fatteners use concentrate feed (grain and wheat bran) and 35.2% of respondents use roughage diet in Mekelle area, Ethiopia. Similarly, Bezahegn et al. (2019) and Estifanos et al. (2014), reported that wheat bran is a common supplementary feed for fattening cattle and Sorghum and chat leftover respectively in West Hararghe, Oromia, Ethiopia. Furthermore, Mumba et al. (2018) and Kamugisha et al. (2017), reported maize bran was the main concentrate supplementary feed in Zambia and Tanzania, respectively.

Smallholder farmers fatten beef cattle either twice per year (46.7%) or once a year (37.9%). This result demonstrates that small landholding farmers in Southern Ethiopia fatten a limited number of cattle (1.88) per fattening season by utilizing locally available feed resources and homemade concentrates which do not satisfy the market requirement. This is lower than reports by Sarma et al. (2014) in Bangladesh, where 47% of smallholder farmers fatten 5-6 cattle every cycle.

In the study area, the period of fattening beef cattle was 3-4 months (by 80.3% of respondents) and 5-6 months (by 10.8%). This is similar to the findings by Berhanu et al. (2018), who reported that smallholder farmers fatten cattle for more than three months in confined conditions in Woliso, Oromia, Ethiopia. Teshager et al. (2013), on the other hand, demonstrated that cattle were fattened for 4-9 months, 10-15 months, and more than 16 months in the Ilu Aba Bora Zone, Oromia region, using the traditional beef fattening system. It was indicated that the fattening period was shorter in highlands than in lowland agroecological due to the availability of different feed ingredients and types for beef cattle fattening from agricultural by-products in most highland and midland areas.

The use of the local market as the primary market source for selling beef cattle may be owing to a lack of market information, insufficient infrastructure, lack of a market-oriented production system, and low quality to meet international market standards including the low selection of animals (weight, using for draft power that affect muscle development and meat quality) for fattening. The majority (86.5%) of the respondents used the local market to get their fattening cattle (Belayneh et al., 2021), is common in the mixed crop livestock production systems of Ethiopia (Tadesse, 2018). This finding concurs with Teshager et al. (2013), who reported that the majority of smallholder fatteners sell beef cattle in village and district local markets to butchers in Illu Aba Bora of Oromia, Ethiopia. According to the present finding, about 8% of beef fatteners sell beef cattle directly to butchers for slaughtering. This is in line with Dinku et al. (2019), who reported butchers usually provide customers with the form of roasted beef "Ethiopian tibs" and raw beef "Ethiopian kurt". Hotel and restaurant owners do occasionally purchase beef cattle directly from producers. Moreover, neighbouring customers occasionally acquire beef cattle from smallholder fatteners, particularly on religious or social and national holidays, by organizing a group of 10-15 people and slaughtering cattle for household consumption. This agrees with Semeneh et al. (2014), who reported commonly, a group of 10-20 people buy a live animal and slaughter it for household consumption.

The current finding revealed that the fasting season, the presence or absence of national holidays, market type and distance, and the size and weight of the animal are the key factors that influence the price of beef cattle on the market. This finding concurred with Teklehaymanot et al. (2017), who found that 25 and 75 % of smallholder beef fatteners use body condition and anticipated price as price determinants during beef cattle marketing in Mekelle, Ethiopia. The present study indicated that smallholder farmers fatten a small number of cattle per household per fattening season after cattle are used for agricultural purposes when they are 4-6 years old.

CONCLUSION

In Wolaita area, beef cattle production is mostly dependent on locally available feed resources, by-products, and homemade concentrates and based on the Ethiopian beef production system classification categorized under by-product-based beef fattening systems. Temperate breeds cattle rarely used for fattening due to their high feed requirement, low adaptation to the area and low availability. Feed resources used as supplementary feeding for beef cattle fattening in the study area are diverse (coffee leaf, cassava-root, enset root) and commonly available in the area. Beef cattle feeding is not based on body weight and nutrient required for cattle. Smallholder farmer fatten beef cattle for short period (3-4 months) after being used for agricultural purpose. Midland has shorter fattening duration than highland and lowland. Main market route of beef cattle in the study area are local market and butcherman through agents. Cattle marketing in the area is mainly based on

color, conformation and age than body weight of cattle. Based on the present finding, the study recommends that modern beef production programs have to be designed to satisfy the demands of the international and national markets. Formal market should be established and linked to the value-chain segment, and beef cattle feeding as well as marketing should be based on the body weight of cattle and age to ensure maximum profitability for smallholder producer. Finally, there should be training and education initiatives for smallholder farmers to overcome the production, feeding and marketing limitations in Wolaita Southern Ethiopia.

ACKNOWLEDGMENTS

Special gratitude goes BTRE for the financial supports. This study is supported by the BRTE, (Building Resilience Through Education), European Union's Horizon 2020 Research and Innovation program under Marrie Sklodowska-Curie Grant agreement No.7781196) of EU.

CONFLICT OF INTEREST

Authors have declared no conflict of interest.

NOVELTY STATEMENT

In tropical countries in including Ethiopia, feed resources for livestock species particularly, for beef cattle varies with climatic condition, and agro-ecology, Even if Wolaita has a unique traditional beef fattening practices, no specific study on local feed resources, traditional beef fattening and husbandry practices in specific setting.

AUTHORS CONTRIBUTION

All the authors contributed for designing research, data collection, data acquisition, data analysis and reporting and manuscript preparation.

REFERENCES

Abebe BK, Alemayehu MT, Haile SM. (2022). Opportunities and Challenges for Pastoral Beef Cattle Production in Ethiopia Advances in Agriculture, Hindawi., https://doi.org/10.1155/2022/1087060.

Agmas B., Adugna M. (2018). Antimicrobial residue occurrence and its public health risk of beef meat in Debre Tabor and Bahir Dar, Northwest Ethiopia. Vet. World. 11(7): 902-908 https://doi.org/10.14202/vetworld.2018.902-908.

Ahmed K., Tamir B., Mengistu A. (2017). Cattle selection criteria and fattening practices in urban and peri urban Kebeles of Dessie and Kombolcha towns, Ethiopia. Online J. Anim. Feed Res., 7(2): 29-37.

Alula T., Guta RM, Bogale G. (2020). Determinants of agricultural commercialization in Offa District, Ethiopia. Cogent Food Agricult., 6(1): 1-11. https://doi.org/10.1080/23311932.2020.1816253.

Ayalew H., Tamru G, Abebe D. (2018). Beef Cattle Fattening Practices and Marketing Systems in Gondar Town, Amhara, Ethiopia. J. Vet. Sci. Technol.; 9: 555. https://doi.org/10.4172/2157-7579.1000555.

Bekuma A., Ayele J, Asefa M. (2020). Evaluation of Beef Cattle Feed Resources, Fattening Practices and Marketing Systems in Selected Districts of Buno Bedele and Ilu Abbabor Zones, Western Ethiopia. American-Eurasian J. Agricult. Environ. Sci., 20 (1): 38-44

Belachew MM. (2019). Beef cattle fattening practices, constraints and future potentials in Ethiopia: a review. Anim. Res. Int.; 16(2): 3401-3411.

Belayneh A., Tassew A, Taye M (2021). Cattle fattening practices and performances in urban and peri-urban areas of Dangila town of Awi Zone, Amhara Region, Ethiopia, Cogent Food Agricult., 7: 1-17. https://doi.org/10.1080/23311932.2021.1963028

Berhanu F., Gebrewahd T, Teklu A, Kiros H, Kumar N. (2018). Beef Cattle Production, Management and Its Constraints in and Around Waliso, Oromia Regional State, Ethiopia. Ethiopian J. Vet. Sci. Anim. Prod., 2(1): 72-80.

Bezahegn A. (2019). Cattle Fattening Practices in West Hararghe: Potentials and Constraints of Beef Cattle Production in Oromia Regional State, Ethiopia. J. Agricult. Sci.; 11(8): 120-128. https://doi.org/10.5539/jas.v11n8p120

Bush RD., Young JR., Suon S., Windsor PA (2014). Forage growing as an incentive to improve smallholder beef production in Cambodia. Anim. Prod. Sci.; 54 (10): 1620-1624. https://doi.org/10.1071/AN14136

Chernet D. (2018). Micro watershed development using GIS & remote sensing in the case of Chille and Ocholo watersheds, Diguna Fango Woreda, Wolaita Zone, Southern Ethiopia. J. Environ. Earth Sci., 8(2): 39-47.

CSA (2020). Agricultural Sample Survey2019/20. Volume II report on livestock and livestock characteristics (private peasant holdings). Central Statistical Agency (CSA): Addis Ababa, Ethiopia.

CSA (2021). Agricultural Sample Survey2020/21. Volume II report on livestock and livestock characteristics (private peasant holdings). Central Statistical Agency (CSA): Addis Ababa, Ethiopia.

Cochrane L, Yishak G. (2018). Data on the demographics, education, health and infrastructure;Wolaita zone, Ethiopia. *Data in Brief*, 21, 2095-2102. https://doi.org/10.1016/j.dib.2018.11.063.

DGWMAO (2014). (Damot Gale woreda in wolaita zone Southern Ethiopia Main Administrative Office).

Dinku A., Abebe B, Lemma A, Shako M. (2019). Beef cattle value chain analysis: Evidence from West Hararghe Zone of Ethiopia. Int. J. Agricult. Sci. Food Techno., 5(1): 077-087. https://doi.org/10.17352/2455-815X.000046

Dinku A. (2019). Assessment of constraints and opportunities in small-scale beef cattle fattening business: Evidence from the West Hararghe Zone of Ethiopia. Int. J. Vet. Sci. Res.,5(2): 058-068. http://dx.doi.org/10.17352/ijvsr.000042

Duressa D, Kenea D, Keba W., Desta Z., Berki G., Leta G., Tolera A. (2014). Assessment of livestock production system and feed resources availability in three Villages of Diga

District Ethiopia, ILRI: Addis Ababa, Ethiopia.

Estefanos T., Tesfaye A, Feyisa H, Gashaye W, Tatek W, Tesfaye K, Osho T. (2014). Traditional cattle production in the highlands of Hararge: Case study for East and West Zones of the high lands of Hararghe, Eastern Ethiopia. Basic Res. J. Agricult. Sci. Rev., 3(12): 122-130.

FAO (Food and Agriculture Organization) 2018: World Livestock: Transforming the livestock sector through the Sustainable Development Goals. Rome. 222 pp. https://doi.org/10.4060/ca1201en. Licence: CC BY-NC-SA 3.0 IGO.

FAO (Food and Agriculture Organization) (2015). Analysis of Price Incentives for Live Cattle in Ethiopia. Technical Notes Series, Food and Agriculture Organization (FAO). Rome, Italy.

Gebremariam S., Amare S., Baker D., Solomon A., Davies R. (2013). Study of the Ethiopian live cattle and beef value chain. ILRI Discussion Paper 23. Nairobi: International Livestock Research Institute.

Gbemichael T., Gebrewahd TT, Kumar N. (2017). Assessment of beef cattle fattening practices and its challenges in and around Mekelle, Tigray, Ethiopia, Ethiopian Vet. J., 21(1):29-39. https://doi.org/10.4314/evj.v21i1.3

Issack HA. Bisrat A., Berhe N., Hailay G., Reda M (2017). Comparative study on live weight and carcass percentage of four indigenous cattle breed in Abergelle export abattoir, northern Ethiopia. Ethiopian J. Vet. Sci. Anim. Prod., 1(1): 17-24.

Kamugisha PP., Modem NSY, Mtenga LA. (2017). Characterizing the Tanzanian quality beef supply chain; a case of Arusha and Dar-es-Salaam cities. Livest. Res. Rural Develop., 29(7):1-12.

Le Gal, E., Molinier N. (2006). Agricultural and economic analysis-diagnosis of Obe Jage (Damot Gale, Wolayta). Institut National Agronomique ParisGrignon.

Ministry of Agriculture (MOA), (2004). Livestock Services Project. Volume 1 (Credit application to the IDA). Livestock and Meat Board, Addis Ababa, Ethiopia, pp: 31.

Mumba C., Häsler B., Muma JB., Munyeme M Sitali DC, Skjerve E, Rich KM (2018). Practices of traditional beef farmers in their production and marketing of cattle in Zambia. Trop. Anim. Health Prod., 50: 49-62. https://doi.org/10.1007/s11250-017-1399-0

National Meteorological Service Agency (NMSA). (2018). Rainfall and temperature records of Duguna Fango woreda. National Meteorological Service Agency (NMSA).

Sarma PK., Raha SK, ørgensen HJ. (2014). An economic analysis of beef cattle fattening in selected areas of Pabna and Sirajgonj Districts. Journal of Bangladesh Agricultural University. 12(1): 127-134. https://doi.org/10.3329/jbau.v12i1.21402

Shapiro B.I., Gebru G., Desta S., Negassa A., Nigussie K., Aboset G., Mechale. H. (2017). Ethiopia livestock sector analysis. ILRI Project Report. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Semeneh S., Jo C., Lee M. (2014). Meat Consumption Culture in Ethiopia. Korean J. Food Anim. Sci.; 34(1): 7-13. https://doi.org/10.5851/kosfa.2014.34.1.7

Tadesse D (2018). Characterization of cattle fattening and marketing systems and nutritional quality of sorghum stover ensiled with effective microorganisms (em) and urea in west hararghe. Addis Ababa University. PhD dissertation.

Teklehaymanot G., Tsegay T, Gebrewahd, Niraj K. (2017). Assessment of beef cattle fattening practices and its challenges in and around Mekelle, Tigray, Ethiopia. Ethiopian Vet. J., 21 (1): 29-39. https://doi.org/10.4314/evj.v21i1.3

Teshager A., Duguma B, Taye T. (2013). Traditional Cattle Fattening and Live Animal Marketing System in Different Agro-Ecologies of Ilu Aba Bora Zone, Oromia, Ethiopia Global Veterinaria., 10 (5): 620-625, ISSN 1992-6197

World Bank, (2017). Livestock and Fisheries Sector Development Project, 1-139

Yamane T. (1967). Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.